EEE 313 - Electronic Circuit Design - Lab 1 Preliminary Report
Tuna Şahin - Diode based Temperature Sensor

Introduction:

For our first lab of the course *EEE 313 - Electronic Circuit Design* we were asked to implement a temperature sensor using the relationship of a diodes' characteristics and temperature. We were then asked to observe the Is of the diode "1N4148" among other observations. We then designed the circuit as a schematic in DipTrace.

Calculations:

My BilkentID is 22201730 therefore I chose my V_{cc} to be 10V.

R_9 and R_{10} calculations:

$R_9 = R_{10} = (V_{cc} - 0.6)/10^{-4} = 94k\Omega$

R_1 and R_2 calculations:

$R_2/R_1(V_{cc} - 2) + V_R = V_{out}$ .We know that $V_R = 2V$ since when the temperature difference is 0, the voltage is given as $(V_{cc} - 2)/4 = 2V$. Therefore $R_2/R_1(8V) + 2V = V_{out}$. The voltage difference is calculated as 1V per kelvin. So we must amplify the actual voltage difference per temperature to have the specified value. The actual voltage per temperature can be calculated from the following formula:

$$V_D \simeq ln(\frac{I_D}{I_s})\frac{nkT}{q} \Rightarrow \frac{\partial V_d}{\partial T} = ln(\frac{I_D}{I_S})\frac{nk}{Q} = 16.2\,mV\,/\,K$$

$$R_2/R_1 \simeq 600$$

Hysteresis value is given as 0.1V. It can also be calculated as the following:
$R_6/R_7(V_{cc} - 2) = 0.1 \Rightarrow R_6/R_7 = 1/80$

to calculate V_H we can take the threshold voltage of $V_{out} = 7V$

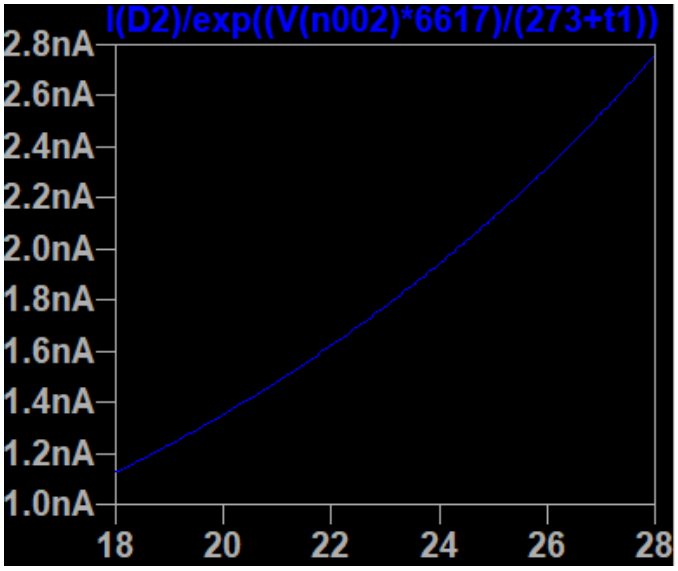
$V_{out} > V_H(R_7 + R_6)/R_7 = V_{out} > V_H\frac{81}{80} \Rightarrow V_H = 6.91V$

From V_H we can calculate R_4, R_5 from voltage divider formula:

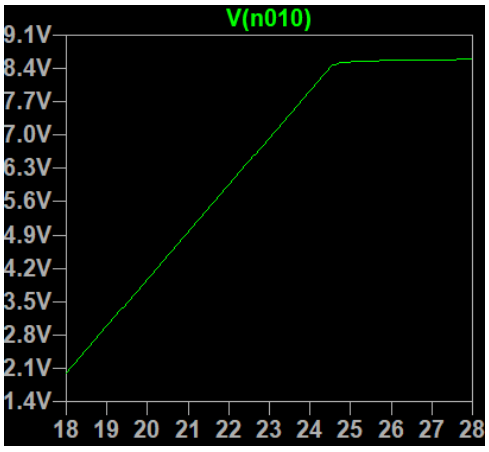
$V_H = V_{cc}\frac{R_3+R_4}{R_3+R_4+R_5} \Rightarrow R_4 = 6137\Omega\,, R_5 = 3863\Omega$

finally the current limiter resistor for the LED can be simply calculated as
$(V_{cc} - 4)/0.01 = 600\Omega$

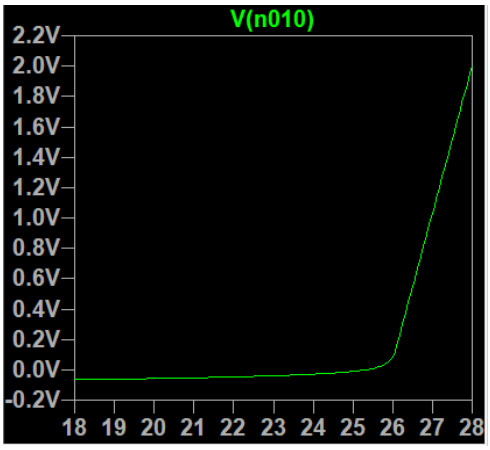
LTSpice Simulations:



We measure the V_d and I_d of any 1N4148 Diode. Value of I_s is given according to the formula: $\frac{I_d}{exp(\frac{V_d q}{nkT})} = I_S$ .The I_s of the diode is seen to be in the neighborhood of 2.5nA at 300K.

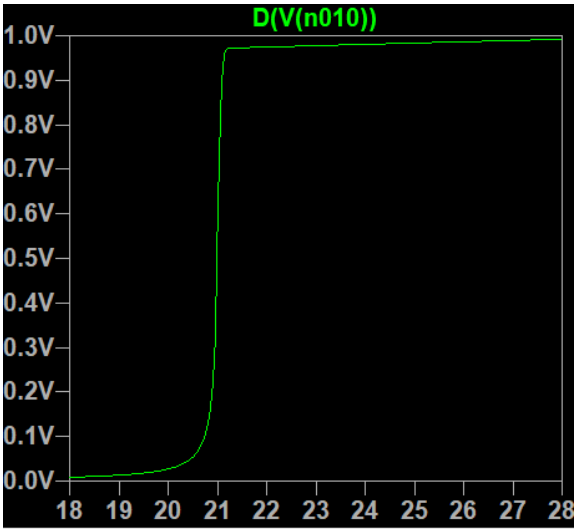


Reference Diode Temperature = 18

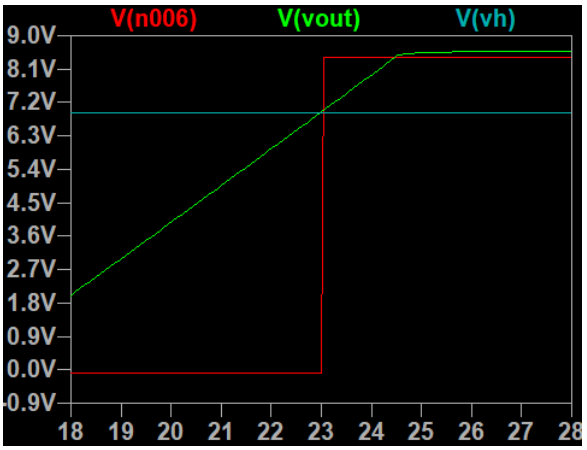


Reference Diode Temperature = 28

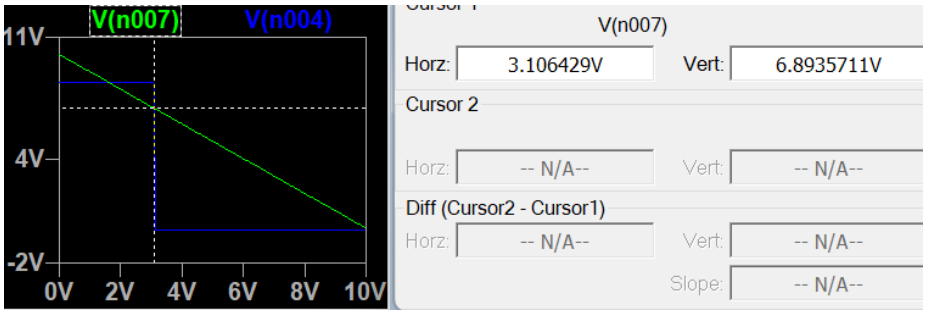
The graphs plot V_{out} –Temperature relation. At 18,18 and 28,28 the voltage is 2V



The graph of $\frac{dV_{out}}{dT}$. The graph stays at 0 when the OPAMP output is saturated at 0V. Then settles at a slope of 1V/K

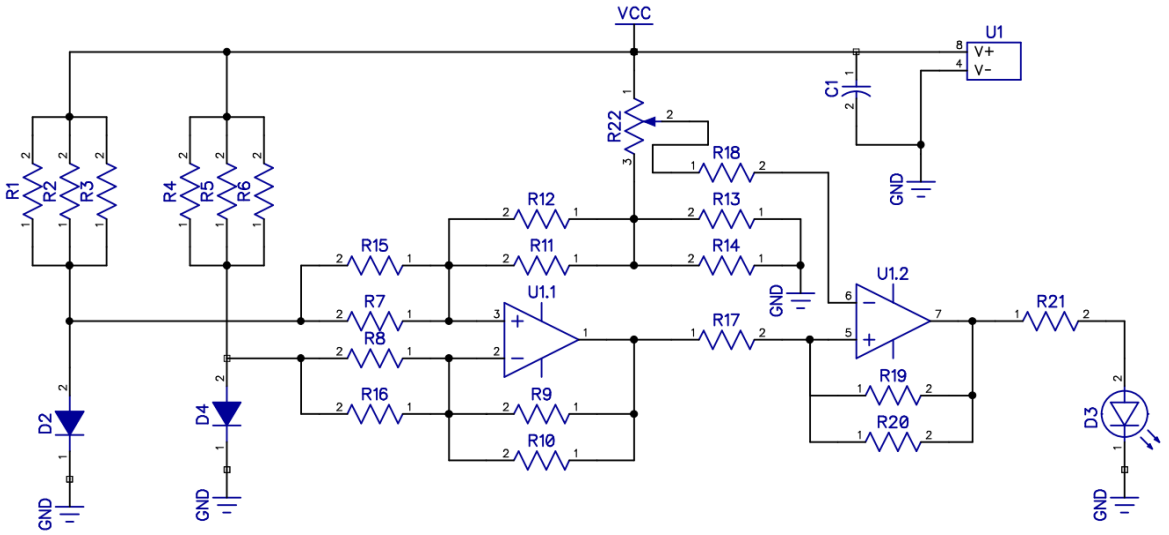


the comparator output turning on after the +5 point is reached (reference diode temperature is 18 in this example)



When the hysteresis comparator is connected to another voltage source to sweep downwards, we can observe that the fall happens very close to 6.91. Turn on point was 7.01 while the turn off point was 6.91.

DipTrace Schematic:



Component List:

- 2 x 1N4148 Diode
- 1 x LM358 Dual Opamp
- 1 x Red LED
- 1 x 100nF capacitor
- 1 x 10kΩ potentiometer
- 2 x 12kΩ resistor
- 2 x 68kΩ resistor
- 2 x 120kΩ resistor
- 4 x 2.2kΩ resistor
- 4 x 1.2MΩ resistor
- 1 x 2.7kΩ resistor
- 1 x 33kΩ resistor
- 2 x 1kΩ resistor
- 1 x 100kΩ resistor
- 1 x 390kΩ resistor
- 1 x 680Ω resistor